

- 1 -

**"Atmosphere control during continuous heat treatment  
of metal strips"**

The present invention relates to a method for the heat treatment of metallic strips comprising, inside a heat treatment chamber  
5 having a pressure greater than atmospheric pressure,

- passing the strip through at least one heating zone of the chamber,

- moving the strip through at least one cooling zone of the chamber, and

10 - establishing a first protective gas atmosphere containing nitrogen and a first hydrogen and/or helium content in the chamber, with the exception of at least one cooling zone, in which there is adjusted a second protective gas atmosphere containing nitrogen and a second hydrogen and/or helium content greater than the said first content.

15 Furnaces for treating strips or sheets moving continuously have been known for a long time. These are used for example for the continuous annealing or continuous galvanisation of steel strips, as well as other types of installation where the strips are treated under a protective atmosphere.

20 These furnaces can contain one or more heating zones, with preferably a temperature maintenance zone, as well as one or more cooling zones, possibly separated by a over-ageing or equalisation zone.

In order to protect the moving sheet against any oxidation, it is known how to protect it by means of an atmosphere gas which may be  
25 nitrogen or a mixture of nitrogen and a small amount of hydrogen and/or

helium. At the same time this atmosphere gas maintains in the chamber of the furnace a pressure slightly greater than atmospheric pressure.

Given the good heat transfer between the strip at high temperature and the hydrogen gas or helium gas, provision has already  
5 been made for adjusting, in a rapid cooling or quenching zone, an atmosphere of protective gas containing a mixture of nitrogen and hydrogen and/or helium with an appreciably greater hydrogen and/or helium content compared with that of the atmosphere prevailing in the rest of the enclosure (see for example JP-55-1969, FR-A-2375334, EP-  
10 B-0 795 616 and EP-B-0 815 268).

These installations require a rigorous partitioning as impermeable as possible between the cooling zone and the rest of the chamber, which involved the application of complex and expensive sealing devices at the entry to and exit from this zone. These devices  
15 generally comprise seals between which the strip must pass, with the risk of damaging the strip, and airlocks where inert gas is injected. Moreover, all these installations must necessarily provide one or more mixers where on the one hand hydrogen and/or helium and on the other hand nitrogen are mixed in the various required proportions before the introduction of  
20 the gaseous mixtures into their respective zone. The result is therefore here also an increase in the overall cost of the installation and a not insignificant additional bulk thereof through the presence of these mixers.

The aim of the present invention is to resolve these problems by developing a method for the heat treatment of metallic strips under an atmosphere of protective gas which allows effective cooling of  
25 the strip and is simple and of reasonable cost.

These problems have been resolved, according to the invention, by a method as described at the beginning, which comprises:

- at least one introduction of nitrogen into the chamber,

- at least one injection of protective gas containing a third hydrogen and/or helium content greater than the said second content into the said at least one cooling zone having the said second atmosphere.

5                   - a gaseous exchange between at least one zone of the chamber having the said first atmosphere of protective gas and the said at least one cooling zone having the said second atmosphere, and

                  - control of the flow rate of the said at least one introduction and the said at least one injection according to the gaseous exchange  
10 between zones, the pressure in the chamber and the hydrogen and/or helium contents to be obtained in the said first and second protective gas atmospheres.

                  This method offers the advantage of not requiring any sealed partitioning system between zones of the chamber since on the  
15 contrary gaseous exchange between the zones is sought, and it provides no pre-mixing of different gases before they are introduced into the chamber. In addition, there is no additional consumption of hydrogen and/or helium gas since the total level remains the level usually used for this type of installation. Moreover, the hydrogen and/or helium gas is  
20 maintained in a greater proportion in the cooling zone, which improves the efficacy of the cooling and reduces any oxidation caused by stray entry of air at the seals and sheaths.

                  Nitrogen gas, in the introductory step, means not only a pure gas but also an industrial gas marketed as nitrogen gas, and which  
25 may contain small proportions of other elements, in particular hydrogen or helium.

                  Advantageously, the protective gas containing the said third hydrogen and/or helium content is hydrogen gas or helium gas. Hydrogen gas or helium gas means not only a pure gas but also an  
30 industrial gas marketed as hydrogen or helium gas, but able to contain

elements in small proportions. It can also comprise a gas containing hydrogen and nitrogen which comes directly from an industrial process but without there being a mixture of the two elements. For example, it is possible to obtain such a gas by cracking ammonia  $\text{NH}_3$  into a product  
5 which contains 75%  $\text{H}_2$  and 25%  $\text{N}_2$ .

According to an advantageous embodiment of the method according to the invention, it comprises, in the said at least one cooling zone having the said second atmosphere, an induction of the protective gas into a recirculation circuit, its cooling and its putting back into  
10 circulation in this at least one zone from the said circuit.

According to an improved embodiment of the method according to the invention, by the said flow control, it comprises, in the said at least one cooling zone having the said second atmosphere, maintenance of a pressure greater than the pressure of the chamber  
15 outside this cooling zone.

Other embodiments of the invention are indicated in the accompanying claims.

Other details and particularities of the invention will emerge from the description given below, non-limitingly and with reference to the accompanying figure, of an installation for implementing a variant of the  
20 method according to the invention.

The single figure depicts schematically a furnace for the continuous annealing of sheet metal in a protective gas atmosphere.

A furnace for the continuous annealing of moving steel  
25 sheets generally consists, in the direction of movement of the product, of the following sections: pre-heating, heating, temperature maintenance, cooling by gas jets, over-ageing or equalisation and final cooling.

The single figure shows solely the central part of the furnace 1 with a temperature maintenance section 2, a rapid cooling  
30 section 3 and an over-ageing section 4. The other sections have been

omitted for ease of reading the figure. The metal sheet 5 moves through these sections in the direction of the arrows.

In sections 2 and 4, the metal sheet is caused to move vertically by turning around return rollers 6. In the cooling section 3, an  
5 intense recirculation system for atmosphere gas is used. This system comprises, in the examples illustrated, two successive cooling zones each containing two vessels for projecting gas onto the metal sheet 7, 8 and 9, 10 placed on each side of the metal sheet, these vessels being provided with nozzles or slots for blowing gas onto the metal sheet. The  
10 recirculation system also comprises an induction conduit 11-14, provided at 15-18 with a fan and a heat exchanger, as well as a discharge conduit 19-22 connected to the corresponding vessel.

The various sections 2 and 3 as well as 3 and 4 are mutually connected by a connecting tunnel 23 or 24, preferably having a  
15 contraction 25 or 26. These tunnels cannot be made airtight and must therefore, according to the invention, allow gaseous exchange between the sections. Though guide rollers, for example the rollers 27, can be provided in these tunnels or contractions, they can under no circumstances serve to seal them.

20 The sections 2 and 4 are supplied with atmosphere gas from the source 28, which, in the example illustrated, is a source of pure nitrogen gas. This source is connected by the conduits 29, 30 and 31 to the various sections, by means of valves 32 and 33. The flow rate can be adjusted at the source 28 or for example by means of valves 32 and  
25 33.

The section 3 is supplied with atmosphere gas from the source 34 which, in the example illustrated, is a source of pure hydrogen gas. This source is connected by the conduits 35 to 37 to vessels 7 to 10 of the cooling section 3, by means of valves 38 and 39. The flow rate  
30 can be adjusted at the source 34 or for example by means of the valves

38 and 39. The conduits 35 to 37 can introduce the protective gas at points other than the vessel, for example directly in the cooling section or advantageously in the recirculation circuit, upstream of the corresponding fan.

5                   As depicted in broken lines, it can also be envisaged supplying nitrogen gas in the section 3 from the source 28, for example by means of the conduit 40 of the valve 41.

The functioning of this furnace is as follows:

10                   In the sections 2 and 4 of the furnace, the pure nitrogen is injected from the source 28, the flow rate being slaved to the pressure which must preferably prevail in these chambers. It is preferable for the pressure to be greater than atmospheric pressure in order to prevent an infiltration of outside air inside the chamber to the maximum possible extent.

15                   Provision can also be made for obtaining a pressure of 1 to 3 mbar in these sections, for example around 1.5 mbar.

                    In the cooling section, pure hydrogen is injected from the source 34.

20                   In each section known instrumentation is provided for measuring the incoming gas flow, the pressure and the hydrogen level.

                    The total of the nitrogen and hydrogen flows introduced into the chamber is advantageously around 400 to 1000 Nm<sup>3</sup>/h, according to the size of the chamber.

25                   The intense recirculation system of the cooling section 3 has a flow rate from 1000 to 5000 times the total atmosphere gas flow introduced to the chamber of the furnace. There is therefore an instantaneous mixing of the hydrogen injected into the recirculated volume, given the high ratio between the flow injected and/or introduced into the chamber (N<sub>2</sub> + H<sub>2</sub>) and the recirculated flow.

By controlling the flow rate of injection of hydrogen into the cooling section, it is possible to immediately regulate the required H<sub>2</sub> content, for example to an order of magnitude of 5% to 25% by volume, or possibly even 50% by volume. It is for example possible after filling  
5 the chamber with nitrogen to inject hydrogen into the cooling section. It is also possible, simultaneously with the introduction of nitrogen into the sections 2 and 4, to inject separately, into the cooling section, nitrogen (through the conduits 40) and hydrogen (through the conduits 36 and 37), in the required proportions, then mixing, as indicated above, being  
10 instantaneous by virtue of the recirculation system.

The flow of hydrogen in the cooling section or the separate flows of hydrogen and nitrogen in this section can be determined and slaved according to a required pressure, preferably greater than that of the other areas, and for example equal to 3 mbar, and according to the  
15 average hydrogen level required in the rest of the furnace.

In operation, the amount of hydrogen in the cooling section can be modified by varying the hydrogen injection rate. The amounts of hydrogen before and after the cooling section can be controlled by modifying the rates of introduction of nitrogen into these sections  
20 upstream and downstream, and therefore the pressures which prevail therein. For example, if the pressure is increased upstream of the cooling zone compared with that downstream of this zone, the nitrogen/hydrogen mixture present in the cooling section will preferentially diffuse in the downstream area and will increase the  
25 amount of hydrogen therein.

In general terms, in the sections of the furnace other than the cooling ones it is possible to provide an amount of hydrogen of around 3% to 5% by volume.

It must be understood that the present invention is no way  
30 limited to the embodiments described above and that many modifications

- 8 -

can be made thereto without departing from the scope of the accompanying claims.